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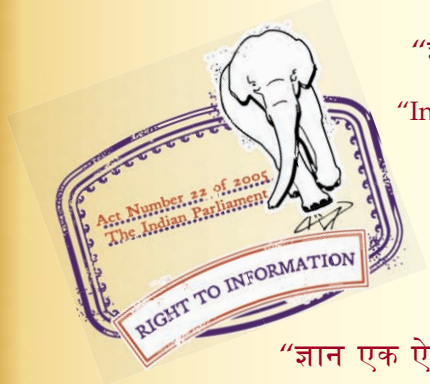

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SPECIFICATION FOR TUNGSTEN RODS AND TUNGSTEN WIRE FOR LAMPS AND ELECTRON DEVICES

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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June 1987

Indian Standard

SPECIFICATION FOR

TUNGSTEN RODS AND TUNGSTEN WIRE FOR LAMPS AND ELECTRON DEVICES

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SPECIFICATION FOR TUNGSTEN RODS AND TUNGSTEN WIRE FOR LAMPS AND ELECTRON DEVICES

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 28 November 1986, after the draft finalized by the Special Alloys Sectional Committee, had been approved by the Structural and Metals Division Council.

0.2 Tungsten is a refractory metal having a high melting point and low vapour pressure, and produced by the powder metallurgy technique. The principal uses of non-sag tungsten wires are in lamps and vacuum tubes. Tungsten also finds application as grids, cathodes, glass-to-metal seals, electrical contacts, welding electrodes, electrode for resistance welding and spark plugs, vacuum metallising and in high temperature furnaces.

0.3 This standard has been prepared as a guide to the manufacturers and the users of non-sag tungsten wires for obtaining the desired characteristics in the filament wires.

In the preparation of this standard, necessary assistance has been derived from the following standards:

a) ASTM F 288 Tungsten wire for electron devices and lamps.

b) JIS H 4461 Tungsten wires for lamps and vacuum tubes.

0.4 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

*Rules for rounding off numerical values (revised).

1. SCOPE

1.1 This standard covers the requirements of two types of drawn tungsten wires suitable for fabrication of parts for lamps and electron devices, and tungsten rods for glass-to-metal sealing.

Type 1 Non-sag. tungsten wire

Type 2 Pure tungsten wire/rod for glass-to-metal sealing.

2. SUPPLY OF MATERIAL

2.1 The general requirements relating to the supply of this material shall conform to IS :1387-1967*.

3. CHEMICAL COMPOSITION

3.1 The chemical composition of the material, when analyzed in accordance with the methods specified in **D-l** shall be as follows:

Tungsten	99·95 *Min*
Iron	0.01 *Mux*
Molybdenum	0·02 Max
Non-volatile matter	0·01 *Max*

NOTE 1 — Desirable molybdenum content is 100 ppm *Max.*

NOTE 2 — The material shall be suitably doped to impart the non-sag properties to the wire.

4. FINISH

4.1 The tungsten wires and rods shall be supplied in the following finishes, as stated in the order:

Finish 1 Black as drawn

Finish 2 Electro polished

Finish 3 Chemically cleaned

Finish 4 Chemically cleaned and stress relieved

Finish 5 Reducing atmosphere cleaned and annealed

Finish 6 Centreless ground for rods

5. FREEDOM FROM DEFECTS

5.1 The tungsten wire shall be smooth free from twists, bends, kinks, curls, swaging marks, scratches, die marks, splits, slivers, pits, grooves, cracks and other physical defects when observed under a 30 X magnification.

*General requirements for the supply of metallurgical meterials (first *revision*).

5.2 Unless black finish is specified, all types of wires shall have a clean finish free from graphite, grease, oil and lubricants. All finishes shall be free from dirt, oxide, stains, scale and other surface contaminations.

5.3 Tungsten rods shall be bright, smooth, free from surface flaws, and be capable of making acceptable glass-to-metal scale.

6. REQUIREMENTS

6.1 Tensile Strength — The tensile strength of the wires of gauge length of 200 mm shall conform to the requirements given in Table 1 when tested in accordance with D-2.

TABLE 1 TENSILE PROPERTIES OF NON-SAG TUNGSTEN WIRE

Mass of Wire mg/200 mm	Dia of Wire in mm (Approx)	Tensile Strength g/mg/200 mm		
		Finishes 1, 2 & 3	Finish 4	Finish 5
up to 1.95	up to 0·03	80 — 110	70 — 90	55 — 95
over 1.95 to 7.91	Over 0·03 to 0·05	75 — 105	70 — 90	55 — 90
Over 7·91 to 17'60	Over 0·05 to 0·08	70 — 100	60 — 90	55 — 90
Over 17·60 to 48·25	Over 0·08 to 0·13	65 — 95	60 — 85	50 — 85
Over 48·25 to 198'00	Over 0·13 to 0·25	60 — 90	60 — 85	50 — 85
Over 198.00 to 760·00	Over 0·25 to 0·51	50 — 80	55 — 80	

(Tensile strength in MPa = 37.65 x tensile strength in g/mg/200 mm)

6.2 Non-Sag Properties — Acceptance of non-sag wire characteristics for particular application shall be the agreement between the producer and the consumer based on Dimensional Measurement limits when determined in accordance with the methods given in Appendix A.

6.3 **Winding Strength** — The wires shall not break, or develop fissure, crack, burrs, etc, when it is subjected to cold winding test in accordance with D-3.

6.4 **Heating Brittleness** — The wires shall not break or develop fissure, crack, burrs, etc, when subjected to heating brittleness test in accordance with D-4.

6.5 **Straightness** — The wires of finish 4 and 5 less than 100 μm in diameter shall have a natural hanging length of 800 mm for a wire length of 1 000 mm. The wires more than 100 μm in diameter, when cut to a length of 200 mm shall have a maximum height of less than 10 mm for a chord length of 100 mm. Higher diameter wires or rods shall be cut to the specified length and placed on a smooth surface and height corresponding to the length of the chord shall be measured.

6.6 Surface Flaws — Tungsten rod (Type 2 j for metal-to-glass sealing shall he free from surface flaws when tested in accordance with the method given in Appendix B.

7. DIMENSIONS, MASS AND TOLERANCES

7.1 Tungsten wire qf diameters below 0·76 mm are determined and expressed as milligrams per 200 mm (mg/200 mm). Cutting and weighing are easier and more accurate than direct measurement of diameter. The mass of a length of wire is proportional to its cross section and to the square of its diameter. The relationship of rating of diameter is

$$\text{mg/200 mm} = FD^2$$

where

F is the conversion factor, and ***D*** is the diameter in mm.

Value of ***F*** = 3011 based on density of tungsten as 19·17 gm/cc.

7.2 Since most of the tungsten wires are used for electrical current carrying purposes which is dependent on the cross sectional area and the diameter of the wire the tolerances on diameter are very critical. Dimensional tolerances for Non-sag tungsten wire shall conform to the requirements specified in Table 2. Determination of the diameter by the method of weighing is given in Appendix C.

TABLE 2 PERMISSIBLE VARIATIONS IN MASS AND SIZE

MASS OF WIRE mg/200 mm	DIMENSIONAL TOLERANCES	SIZE UNIFORMITY WITHIN A SPOOL
Up to 0·36	± 4 percent on mass	0·02 mg/200 mm
Over 0·36 Up to 0·67	± 4 percent on mass	0·02 mg/200 mm
Over 0·67 Up to 2·0	± 2 percent on mass	0·02 mg/200 mm
Over 2·00 Up to 760	± 1·5 percent on mass	1 percent by mass
Over 760	± 1·5 percent on diameter	—

7.3 Out-of-roundness of wire or rod shall be within 5 percent of the maximum diameter.

8. COILING AND SPOOLING

6.1 Tungsten wires shall be furnished in one continuous length and wound smoothly with no loose turns. There shall be no pilling up of turns such as to prevent free unwinding or cause kinks or bends when the wire is removed from the spool. The outer end of the wire shall be attached firmly to the spool by suitable means and shall be visible.

8.2 Spools and seams shall be clean and free of open seams or projections which might catch or tangle the wire during winding or unwinding.

8.3 The minimum length of wire in each spool shall be as indicated below:

300 metres for wire sizes up to O-35 mg/200 mm (excluding 35)
200 metres for wire sizes up to 35-50 mg/200 mm (excluding 50)
100 metres for wire sizes up to 50-100 mg/200 mm (excluding 100)
50 metres for wire sizes over 100 mg/200 mm

NOTE — The average length of wire in each lot shall be not less than 1·5 times the minimum length specified above.

8.4 Spools and bands shall conform to the dimensions as agreed to between the manufacturer and the purchaser.

9. BASIS OF PURCHASE

9.1 Orders for tungsten wire and rods covered by this specification shall include the following information:

a) Type,
b) Length of wires,
c) Finish,
d) Mass or size and tolerance, and
e) Specification number.

10. PACKING AND MARKING

10.1 Spools and bands containing tungsten wires shall be packed in suitable containers to avoid damage during transit and storage. Small bags of silica gel if required shall be placed inside the container for moisture absorption. Each spool shall be marked with the name of the manufacturer mass in mg/200 mm or the diameter in mm or both at begining and end of wire on a spool, manufacturer's type number, lot number, date of manufacture and length in metres.

10.2 The material may also be marked with the Standard Mark.

NOTE — The use of the Standard Mark is governed by the provisions of the Bureau of Indian Standards Act 1986 and the Rules and Regulations made thereunder. The Standard Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well defined system of inspection, testing and quality control which is devised and supervised by BIS and operated by the producer. Standard marked products are also continuously checked by BIS for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

APPENDIX A

(Clause 6.2)

SAG DETERMINATION TEST

A-1. TEST PIECE

A-1.1 Tungsten wire having a diameter of 0·76 mm shall be taken as test pieces.

A-2. TEST METHOD

A-2.1 Bell Jar Envelope — A suitable envelope surrounding the test apparatus. The envelope may consist of a glass bell jar, preferably of a heat-resistant glass or may be constructed of metal, in which case a transparent window shall be provided in order that the behaviour of the specimen under test may be observed. The envelope may be rigidly supported in a fixed position or may be suspended in such a manner that it can be raised or lowered into position over the test apparatus. A means shall be provided for maintaining within the envelope an atmosphere and steady supply flow of hydrogen. A flow meter shall be incorporated in the hydrogen line so that measurement and control of the gas flow may be maintained. The hydrogen line shall discharge at the upper levels of the envelope and shall be baffled by a suitable diffusing device so that no direct stream of the gas will play upon the test specimens.

A-2.2 **Specimen Support —** A suitably designed support and clamping device for holding the specimen within the envelope during testing. This support, which may be rigidly fixed or capable of being raised into or lowered from the envelope, shall be made from a suitable metallic conductor so that electrical current from the power supply may be used to heat the test specimen. An insulated clamping fixture shall be provided at the top of the support so that the hairpin test specimen will be firmly held. This clamping device shall be capable of rotating 90 deg on its axis in order that the test specimen may be heated both in a vertical position with its apex down and in a horizontal position. A means shall be provided for accomplishing this rotation without requiring the removal of the test specimen from the clamping fixture.

A-2.3 Hydrogen used for the test atmosphere shall have a purity meeting the following requirements:

a) Moisture (water), not more that 2·5 g/28 m^3 as indicated by a dew point of -65°C or below;

b) Oxygen, not more than 10 ppm;

c) Hydrocarbons (plus CO and CO_2), not more than 20 ppm; and

d) Nitrogen, not more than $\frac{1}{2}$ percent.

A-3. TEST SPECIMEN

A-3.1 Surface — The specimen of tungsten *wire to* be tested for sag shall have a clean, bright surface and shall be at least 400 mm in length.

A-3.2 **Forming** — With the aid of external heat, the test specimen shall be bent into a hairpin-shape until the distance between the ends is 25 mm. The hairpin is formed by bending the wire around a pin whose diameter is approximately twice that of the test specimen. The legs of the formed hairpin shall lie in the same plane.

A-3.3 Test **Length** — The formed test specimen shall be of sufficient length so that when clamped in the fixture, the exposed lengths measured from the top of the apex will not be less than 100 mm.

A-3.4 Test **Weight** — A hook shall be provided for attaching the required weight to the apex of the test specimen. A tungsten wire with a diameter of 2 mm is recommended for use as a hook. The testing weight for sag determination shall be 1·4 kg.

A-4. PROCEDURE

A-4.1 Mount the test specimen vertically downward in the test apparatus. Move the apparatus, with the specimen in place, into the bell jar envelope. Introduce sufficient hydrogen into the bell jar at a positive flow to form a safe protective atmosphere for the test specimen.

A-4.2 After the bell jar envelope is completely flushed with hydrogen, raise the temperature of the test specimen at a constant rate to 2 600 K true temperature in 1 min and hold at that temperature for 5 mm after which lower the current to zero in 1 min at a constant rate.

A-4.3 When the test apparatus has cooled, remove the weight and move the test specimen through an angle of 90 deg so that the plane formed by the legs of the specimen is horizontal. Measure the vertical distance of the apex in millimetres and record as the zero point or initial reading.

A-4.4 Raise the temperature of the test specimen at a constant rate to 2 600 K in 1 min and hold at that temperature for 5 min before removing the power.

A-4.5 When the apparatus and specimen have cooled, measure the sag before *removing* the *specimen* of the apparatus. Measure the vertical distance of the apex of the specimen in millimetres and record as the final reading. The sag is defined as the difference between the initial and final readings after being held at 2 600 K for 5 min.

APPENDIX B

(*Clause* 6.6)

STANDARD TEST METHOD FOR SURFACE FLAWS IN TUNGSTEN SEAL ROD AND WIRE

B-l. SCOPE

B-l.1 This method covers the determination of the presence of surface flaws in tungsten-seal rod and wire of random or cut lengths, and in the tungsten section of multiple-piece-through leads used in electronic devices, by means of examination of a glass bead sealed to the tungsten.

B-2. DEFINITIONS

B-2.1 Fissure — Any narrow opening or cleft in the surface of the tungsten.

B-2.2 **Beaded Length** — The actual length through which a glass-to-tungsten seal exists as evidenced by the colour of the interface.

B-2.3 **Line of Bubbles** — One long or several small bubbles so arranged in the otherwise substantially bubble-free glass bead that they are in an almost straight line immediately adjacent to the tungsten-glass interface.

B-2.4 **Fault** — A tungsten-glass seal in which a fissure, either delineated by a line of bubbles or in itself clearly discernible, is observed when inspected as prescribed in this method.

B-3. APPARATUS

B-3.1 Beading Equipment — Suitable beading equipment capable of producing glass-to-tungsten seals as prescribed in B-4.

B-3.2 Microscope — A low-power microscope capable of magnification up to 30 diameters, preferably of the binocular type.

B-3.3 **Light Source** — A suitable white light source, preferably diffuse for illumination of the bead under the microscope.

B-4. PREPARATION OF TEST SPECIMEN

B-4.1 The test specimen shall be a beaded tungsten rod prepared in the following manner.

B-4.1.1 The surface to be beaded shall be cleaned in the usual manner employed by the user of the tungsten.

B-4.1.2 *Alternative Methods of Specimen Preparation* — In case of disagreement between the manufacturer and the purchaser, one of the following alternative methods shall be substituted of preparing the tungsten rod for that in B-4.1.1.

B-4.1.2.1 The tungsten specimen shall be boiled for 2 min in a 5 percent solution of 27 percent hydrogen peroxide. The hydrogen peroxide shall then be poured off and the specimen shall be rinsed twice in distilled water. The specimen shall be dried rapidly with pure alcohol or in an oven heated to 100°C.

B-4.1.2.2 The tungsten shall be placed in a solution (20 weight percent) of sodium hydroxide or potassium hydroxide and sufficient electrical current shall be passed through it to induce electrolytic action sufficient to clean the specimen.

B-4.2 The cleaned tungsten rod shall be beaded over the area to be examined with glass, of the type and wall thickness commonly used for beading, to a length of not less than 5 mm bead length.

B-4.3 To permit examination of the glass-to-tungsten interface, the bead shall be substantially free from bubbles, from causes other than the tungsten defects, and shall have been so prepared that the surface of the tungsten is clearly visible through the bead.

B-4.4 To colour of the glass-to-tungsten seal shall be such as to indicate the proper application of heat to the bead to obtain a satisfactory seal.

NOTE — The usual preferred seal colour shall be a golden-yellow hue.

B-5. PROCEDURE

B-5.1 The beaded tungsten shall be held in focus under the microscope in such a manner that the beaded length may be observed.

B-5.2 The specimen shall be rotated through 360" on its axis so that the entire surface of the tungsten-glass interface may be examined.

B-5.3 The seal shall be examined under 20 x whether fissures or lines of bubbles are present. If either are present, the seal shall be recorded as a fault.

B-6. REPORT

B-6.1 The report shall include the following:

a) Purchase order number,
b) Diameter of specimens,
c) Number of specimens examined,
d) Magnification used,
e) Cleaning procedure used,
f) Type and nominal wall thickness of glass bead used,
g) Nominal beaded length,
h) Colour of seal, and
j) Number of faults observed.

APPENDIX C

(*Clause* 7.2)

MEASURING DIAMETER OF FINE WIRE BY WEIGHING

C-l. APPARATUS

C-l.1 The apparatus shall consist of a suitable torsion or other direct-reading balance capable of reading to 0·002 mg or 0·1 percent of the weight to be weighed (whichever is larger), with an accuracy of 0·004 mg or 0·2 percent (whichever is larger). The range of the balance (or the size of the specimen) shall be such that the reading will lie within the upper half of the **scale.**

C-2. TEST SPECIMENS

C-2.1 Test specimens shall be located at least 1 m from the end of a spool or sufficiently far from the end to be free from kinks or other damage resulting in lack of straightness of the cut length.

C-2.2 The wire shall be drawn from the spool under a low even tension so that no elongation of the wire takes place.

C-2.3 Each test specimen shall be cut to a length of 200 $\pm$ 0·1 mm. To prevent stretching, care shall be taken so that the tension is just sufficient to eliminate the sag and curl. Any disagreement concerning the amount of tension to be used in cutting shall be resolved between the manufacturer and the purchaser.

C-2.4 The test specimen shall be folded upon itself several times and twisted to make a compact bundle with loop consisting of a single strand for hanging it on the balance beam. In the case of multiple specimens, all specimens shall be twisted together and hung by a loop consisting of a single strand. The specimen shall be handled as little as possible. The operator's hands shall be clean and dry.

C-3. NUMBER OF SPECIMENS

C-3.1 A single specimen shall be weighed if its weight lies within the upper half of the scale of the instrument. When the weight is less than half of the scale of the instrument, a sufficient number of specimens 200 mm in length shall be weighed simultaneously so that the total weight will register in the upper half of the scale, preferably as close to the limit of the balance as possible. An instrument with lowest range compatible with the weight of the 200-mm weight specimen shall be used to reduce the number of 200-mm lengths that must be weighed together.

C-4. REPETITION OF WEIGHING

C-4.1 If the corrected weight of a single specimen lies within ±0·5 percent of either the minimum or the maximum limit specified for the wire weight, two more specimens of wire shall be cut and weighed in a similar manner. When two or more lengths of wire have been weighed simultaneously to produce a reading in the upper half of the scale because of the small size of the wire, two more sets of specimens shall be cut & weighed in a similar manner.

C-5. PROCEDURE

C-5.1 The balance shall be handled and used as recommended by the manufacturer. Particular attention should be given to requirements for careful handling, protection from vibration and atmospheric dust, errors induced by temperature changes and the necessity for avoiding parallax in reading.

C-6. EVALUATION OF RESULTS

C-6.1 If a single specimen or a single set of specimens is weighed, and its corrected weight, or average weight when multiple specimens are used, is found to lie between the point 0·5 percent above the minimum limit and 0·5 percent below the maximum limit, the wire shall be considered to meet the specified limits.

C-6.2 If the corrected wire weight is under 0·5 percent below the minimum limit or over 0·5 percent above the maximum limit, the wire is considered not to meet the specified limits.

C-6.3 If the corrected weight of a single specimen, or the average weight, when multiple specimens are used, lies within the range of ±0·5 percent of the maximum or ±0·5 percent of the minimum limit, exactly three specimens or three sets of specimens shall be weighed, and the average corrected value compared with the maximum and minimum limits. If the average of the three readings lies between the maximum limit and the minimum limit, the weight of the wire is considered to lie within these limits.

NOTE 1 — The following is an example of the evaluation of results. If a specified weight of 8·00 mg/200 mm and a, specified tolerance ± 3 percent (±0·24 mg/200 mm) is assumed, the range determined by these specifications must be 7'76 to 8·24 mg/200 mm. The working zones for weighing will be:

Minimum limit

+0·5 percent, 7·76 + 0·04 = 7·80 mg/200 mm

−0·5 percent, 7'76 − 0·04 = 7·72 mg/200 mm

Maximum *limit*

−0·5 percent, 8·24 − 0·04 = 8·20 mg/200 mm

+ 0·5 percent, 8·24 + 0·04 = 8·28 mg/200 mm

The corrected weight of a single cut length of wire found to lie between 7·80 and 8·20 mg/200 mm will suffice to accept the wire. The corrected weight on a single cut length of wire found to be less than 7·72 mg/200 mm or more than 8·28 mg/200 mm will suffice to reject the wire as outside the specified limits.

If the corrected weight of a single cut length is found to he between either 7·72 and 7·80 mg/200 mm, or 8·20 and 8.28 mg/200 mm, two more pieces shall be cut, weighed and averaged with the first weight. If the average of the three weights lies between 7·76 and 8.24 mg/200 mm, inclusive, the wire is considered to meet the specified range; if outside these limits, it is considered not to meet it.

C-7. TEST REPORT

C-7.1 The report shall consist of the number of readings, and the average corrected weight of the wire to three significant figures in milligrams per 200 mm, except that for sizes under 1 ·00 mg/200 mm only two significant figures shall be reported. The value reported shall be the weight of the outside end of the spool unless it shall have been agreed otherwise between the manufacturer and the purchaser.

C-8. PERMISSIBLE VARIATIONS

C-8.1 Permissible variations from the specified weight shall be designated by maximum and minimum weights, or as a plus-and-minus percentage tolerance to be applied to the normal weight.

C-9. CALCULATIONS

C-9.1 The average diameter of the wire shall be calculated from the following equations from the constants given in Table 1 for several alloys:

$$D = (3{\cdot}141/\sqrt{\triangle}) \times \sqrt{W} = K\sqrt{W}$$

$$(K = 3{\cdot}141/\sqrt{\triangle})$$

$$W = 0.101\ 34\ \triangle D^2 = CD^2$$

$$(c = 0.101\ 34\ \triangle)$$

$$\triangle = (W/D^2) \times 9{\cdot}868$$

where

D = diameter of wire, mils (mils x 0·025 = mm);

$\triangle$ = density of wire, g/cm³;

W = weight of wire, mg/200 mm; and

C and K = constants.

TABLE 1 CONSTANTS FOR DIAMETER CALCULATIONS

ELEMENT	DENSITY, g/cm³	CANSTANTS	
		c	K
Molybdenum	10.14	1.028	0.986
Tungsten	19'17	1.943	0·718

APPENDIX D

(Clause 6)

METHOD FOR CHEMICAL AND PHYSICAL ANALYSIS

D-O. TEST METHODS

D-l. CHEMICAL ANALYSIS

D-l.1 The chemical composition of the tungsten wire and rod shall be determined by any established instrumental/chemical method of analysis. In case of any dispute, the referee method shall be as agreed between the contracting parties.

D-2. TENSILE STRENGTH

D-2.1 Apparatus — Any standard testing machine that applies the load at a constant rate of traverse or a machine calibrated in terms of a constant rate of traverse shall be satisfactory. The capacity of the testing machine shall be such that all specimens fail at greater than 40 percent of the capacity of the machine. The clamps used shall be such that there will be no slipping of, or damage to, the test specimen.

D-2.2 **Procedure** — The tensile strength shall be determined on a specimen of 200 mm length at room temperature. The initial load applied to the specimen before making the test shall be sufficient to keep the wire straight. The rate of traverse shall be 25 mm/min. If the specimen breaks within 12.5 mm of the clamps, the test shall be repeated.

The report shall include the averages of at least three determinations each of the tensile strength and expressed in gf/mg/200 mm or in MPa.

D-3. WINDING STRENGTH

D-3.1 The wires shall show no defect such as breaking, fissure, crack, burrs, etc, when it is subjected to a cold winding test by hanging a weight equivalent to the value of about 10 percent of the tensile strength of the wire, over a mandrel wire having two times the diameter of the original wire and winding by rotating the mandrel for 30 turns.

D-4. HEATING BRITLLENESS

D-4.1 The wires shall show no defect such as breaking, fissures, cracks, burrs, etc, when subject to the test given in D-4.2.

D-4.2 A hydrogen furnace of 25 to 50 mm inside diameter and having uniform heating zone of 200 mm or more in length shall be maintained at a furnace wall temperature of approximately 1 600°C. The test piece of wire shall be placed in a ceramic boat and charged into the furnace. After being heated for one minute at -approximately 1 600°C, the wires shall be tested by the winding method given in D-3.1.

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

QUANTITY	UNIT	SYMBOL
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

QUANTITY	UNIT	SYMBOL
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

QUANTITY	UNIT	SYMBOL	DEFINITION
Force	newton	N	1 N = 1 $kg.m/s^2$
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	HZ	1 Hz = 1 $c/s (s^{-1})$
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 Nim^2